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Smart Disease Prevention App: Informing the Public in Their Own Geographic Location

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SMART DISEASE PREVENTION APP:

Informing the Public in Their Own Geographic Location

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STUDENT AUTHOR BIO SKETCH

Apoorva Sulakhe and **Shefali Rana** are graduate students in the School of Industrial Engineering at Purdue. They have both been teaching assistants under their coauthor, **Dr. Vincent Duffy,** while supervising multiple projects. Coauthors **Zoe Disori, William Nogay, Kyle Plummer, Meredith Shannon, Morgan Young,** and **Alyssa Zielinski** are listed in alphabetical order. They were all seniors in School of Industrial Engineering at the time of this project in 2017. The purpose of their study, described in this article, was to develop an application to provide users with accurate information about diseases spreading in their geographic locations.

INTRODUCTION

Globalization has increased human contact and thus the rate of infectious disease spreading. Recent outbreaks of Ebola and Zika have prompted unexpected needs for fast, correct access to information and resources. Smart health apps help bridge this gap and have a wide impact on reducing hospitalizations and emergency room visits throughout the health care spectrum by improving communication and care coordination among specialists, doctors, nurses, and others. As part of the industrial engineering (IE) 486 Work Analysis & Design II course in 2016, the coauthors learned information that can help design applications lead to betterment of current designs. They observed this gap and decided to pursue this project.

This study aims to provide a smart phone application that streamlines information from many trustworthy sources to bring information and resources to the general public. The application is intended to prevent the spread of disease by providing the user with real-time epidemic tracking, as well as information about the disease symptoms, and where to seek medical attention via the user's current location. Disease outbreak is generally communicated via the media. For some individuals, it would take time for the information to reach them, depending on their environment. Further, most individuals only know the name of the disease and don't know what symptoms or effects the disease has or where to go if they feel they may be infected. The purpose of this application was to inform users of the location of the disease, its symptoms, and its effects. Because this application can be used by people around the world, there needs to be a comparison of how different people use the application. Even more exciting is the prospect of future use, as medical technology continues to evolve to the Internet of Things, the concept that everything in a city (or hospital) can be interconnected via some type of intranet or Internet connection, providing real-time data analysis and data clustering. This leads to faster diagnosis and, in the case of our app, nearly instantaneous analysis of new facets of an outbreak or disease. According to Jolin Adeeb Qutub of George Mason University, "cognitive styles have been found to be significantly associated with cultural background and learners' academic achievements" (Qutub, 2008). Because of these differences in cognition patterns, our team conducted an eye-tracking analysis using Tobii, one of the leading eye-tracking sensor technologies on the market. A set of system testers visually assessed our application, and then they completed a Likert-scale survey to assess the ease of use and determine how often they would realistically use the application. Mobile health apps and devices are making a strong impact in the health care industry, as they may even be able to diagnose disease and prevent the likelihood of developing dangerous medical conditions like heart disease or diabetes. The main task that the system will support is speeding up the access of knowledge about infectious diseases. Expected beneficiaries are those not infected by a certain disease. The main resources will be current data that is available for public use and various resources regarding app development.

METHODOLOGY

The idea for this project was generated by a summary of research for smart systems, and the team decided to pursue a smart system in health care. The course helped in application development and aspects related to cross-cultural design. The goal was to create a user-centered smart application in health care, and the objective was to raise awareness of disease prevention by using the application. To do this, we created a wireframe prototype for an application that tracks diseases spreading across the world and alerts users when a disease is in their area or a place they are planning to travel.

In order to create a more user-friendly design, the team conducted experiments with eye-tracking technology. Both objective data from an eye-tracker test and subjective data from a questionnaire were retrieved for further analysis. The wireframe prototypes shown in Figure 1 were tested on the students of IE 486 using the Tobii eye-tracking software. The experimentation occurred in the Discovery & Learning Research Center near Purdue University Discovery Park. Figure 2 shows the result of the experiments in the form of gaze plots and heat maps during use.

To determine what factors would make the application user-friendly, an analytic hierarchy process (AHP) matrix was created (Saaty, 1996). In order to conduct an AHP analysis, participants were given surveys to fill out while participating in an eye-tracking study of the application. Ease of use, aesthetics, comprehensibility, and functionality of the application were determined to be the most valued criteria. The feedback from the participants was applied to the AHP matrix with their respective weight, and the best prototype was determined. Using those weighted ratings, the features were incorporated into the application prototype. Table 1 shows the AHP matrix.

The analytic hierarchy process can be used in a questionnaire to measure patient preferences for ease of use, aesthetics, comprehensibility, and functionality, but it appears to be only partially valid, depending on which criteria are used in the AHP model. That is, it appears invalid when measuring other traits like sensitivity, specificity, and safety or risks. On the other hand, the correlations show us that when comparing the intention to attend scale with the other scales, it correlates the least with AHP. Therefore, it is questionable whether AHP is the best way to predict impact. However, predicting the intention to attend (or the actual attendance) and eliciting preferences is not the same thing, so the AHP model should be adjusted by selecting different criteria. When this is done, AHP has potential to be a good predictor for

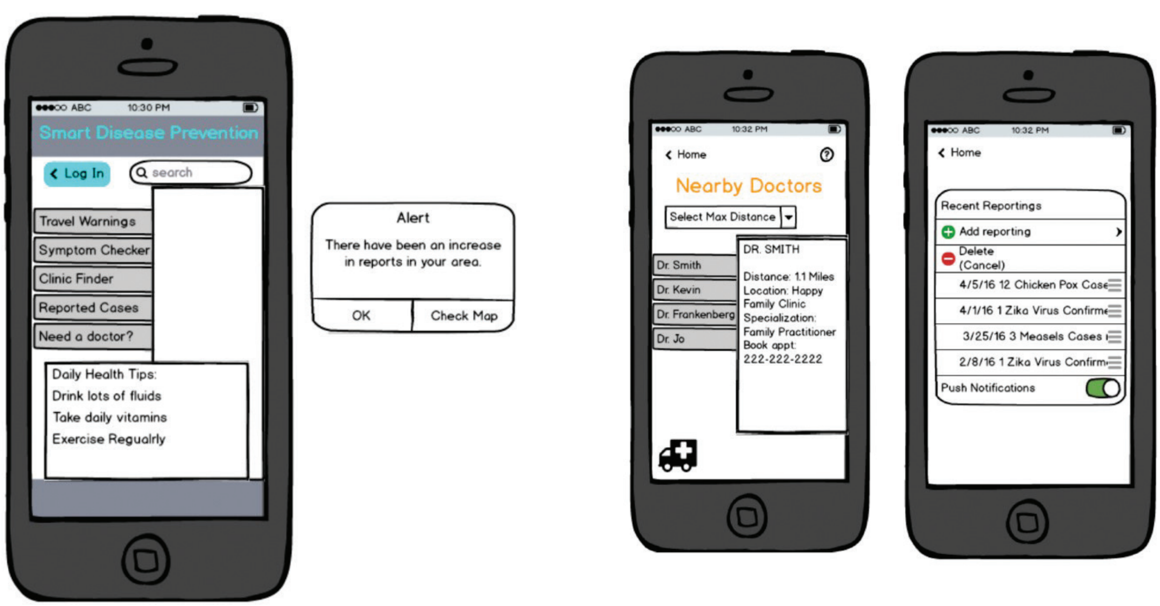

Figure 1. Wireframe prototype of the Smart Disease Prevention application.

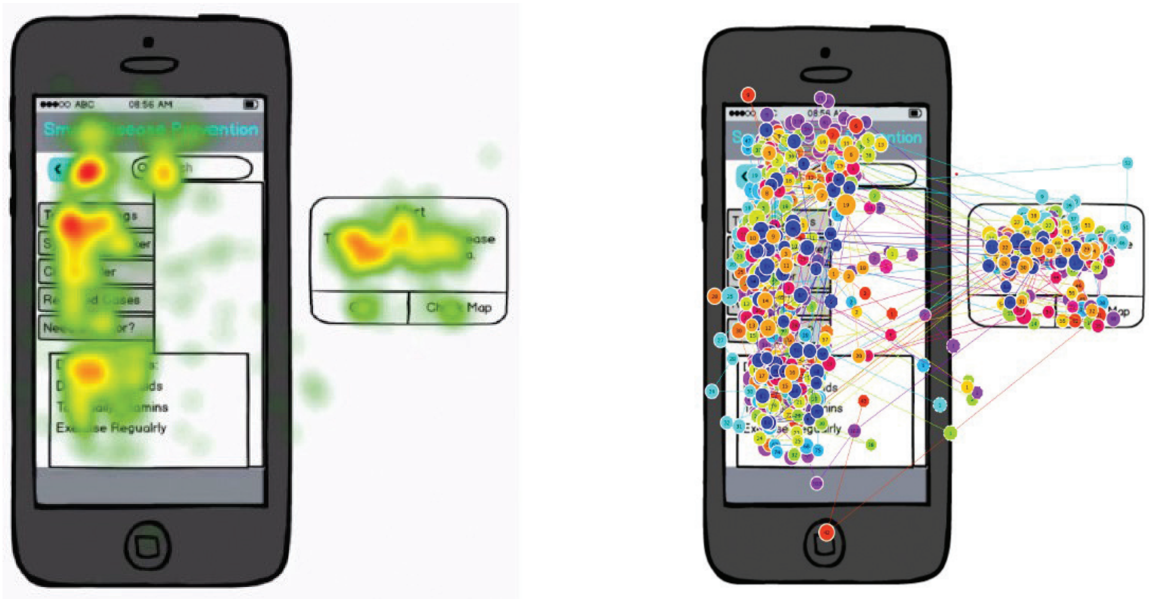

Figure 2. Heat map and gaze plot generated by the eye-tracking software.

the intention to attend or the actual attendance. In this study, we combine the method of AHP with eye tracking to ensure we have full user intent captured. Further, we ultimately combined what many users were looking for on the screen and what they concluded.

This analysis was conducted in a smaller group due to limited time and resources, but the more the application is implemented, the more data will be collected; this in turn creates better-informed users and health professionals. The goal of the application is to reduce the spread of infectious diseases at a global scale through education. The users of the application should be diverse so the app can accommodate as many people as possible. Another exciting part of the application is that constant updates and upgrades can be made. More data would help us generate an accurate diagnosis, so a greater cross-section of testers would be beneficial.

An article about smart services (Medina-Borja, 2015) and a well-known book by Sanders and McCormick (1992) about human factors in design influenced our thinking about human factors, services, and the systems aspects throughout the project. An article that reviewed the use of analytical hierarchy methods in relation to organizational strengths, weaknesses, opportunities, and threats (Yuksel

Appendix B: Likert Scale Questions

1) How likely are you to use this app for travel?
Never Unlikely Occasionally Likely Very Likely

2) How useful would you find this in an emergency?
Never Unlikely Occasionally Likely Very Likely

3) How likely are you to use this with a loved one abroad?

Never Unlikely Occasionally Likely Very Likely

4) How important do you find news and current updates about infectious diseases?
Unimportant Of Little Importance Moderately Important Important Very Important

5) How frequently would you check this app in the case of an infectious disease in your country?
Never Rarely Occasionally Frequently Very Frequently

6) How likely is it that you would recommend this to a medical professional?
Never Unlikely Occasionally Likely Very Likely

7) How likely are you to suggest this app to a friend/family member?
Never Unlikely Occasionally Likely Very Likely

Figure 3. Likert-scale questionnaire.

Table 1. Weighted ratings for the three variation of prototypes.

Criteria	Weight	Prototype 1	Prototype 2	Prototype 3
Usability	0.385	0.155	0.069	0.777
Aesthetic Design	0.052	0.429	0.143	0.429
Comprehension	0.439	0.480	0.405	0.115
Functionality	0.123	0.115	0.405	0.480
Weighted Ratings		0.307	0.262	0.431

& Dagdeviren, 2007) motivated our initial use of AHP in this mobile application development context. Further, an article comparing the use of multiple regression and structural equation modeling (Pugesek & Tomer, 1995) influenced our analyses and model development. One additional article outlining the development of a health index gave insights into the possibilities and examples of measures that could be directly applied in health application development (Yanuar, Ibrahim, & Jemain, 2010).

RESULTS

The data from the questionnaire was combined into one spreadsheet, and the responses for each question were counted and graphed. Of participants, 46% would use the app while they traveled, and 71% would find the application useful in an emergency. In addition, 50% of the participants would use the application while traveling abroad with a loved one, and 68% find the news and current events important when tracking infectious diseases. Further, 50% of the participants would frequently check this app in the case of an infectious disease in their country, and 64% would recommend this app to a family member or friend. These results are graphically represented in Figure 4.

The eye-tracking data allowed us to see what areas of our prototype were viewed the most. The heat map showed the areas that were viewed for the longest amounts of time. The gaze chart allowed us to see the order in which participants looked at different areas of our prototype. It was hypothesized that the relationships among variables (user-friendliness, ease of use, ability to track progress, eye-tracking variable fixation count, and fixation duration) and the preference of using our design product are significant. The test results also revealed the likelihood of users introducing this product to their friends.

Path analysis and factor analysis were conducted to prove the hypothesis. There are five exogenous variables in the path analysis: user-friendliness, ease of use, ability to track progress, eye-tracking variable fixation count, and fixation duration. For factor analysis, three distinct factors were hypothesized to be significant: subjective exogenous variables, objective exogenous variables, and subjective endogenous variables. In the path analysis, all subjective exogenous variables are significant at a p-value of 0.001, while the objective exogenous variable mean duration does not show the significance (Tables 2 and 3). Fixation count, user-friendliness, and ease of use

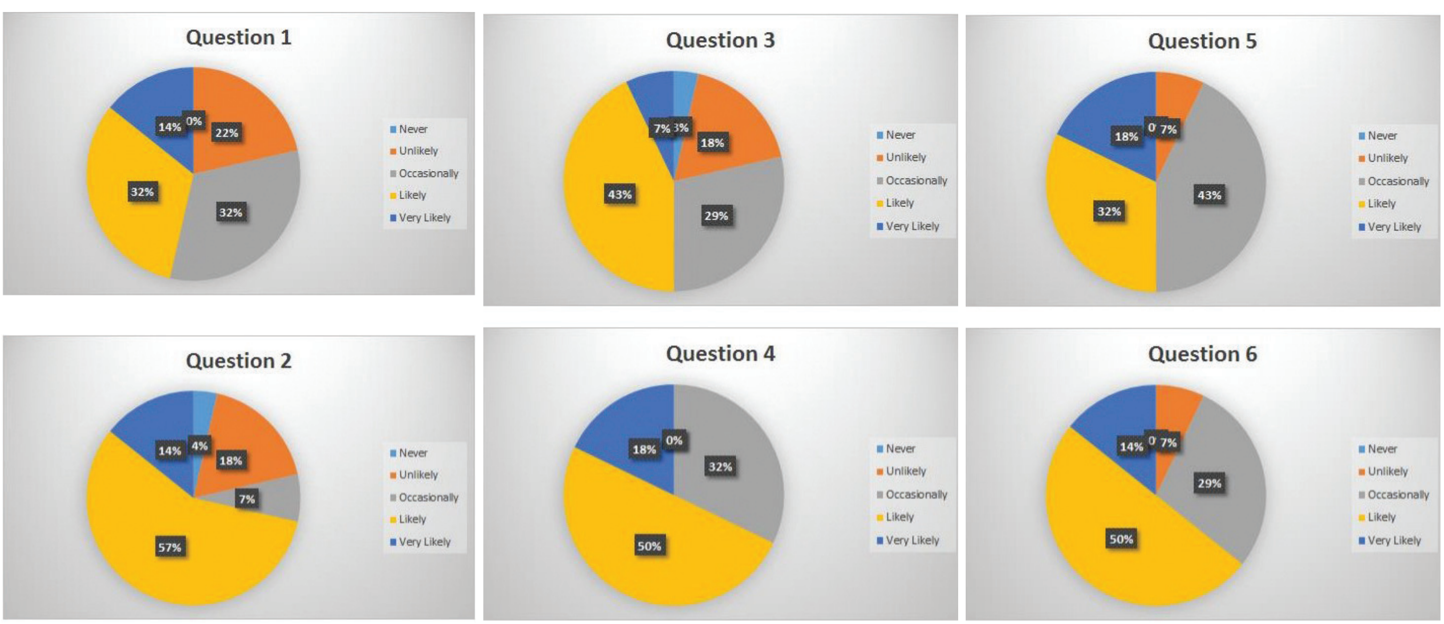

Figure 4. Graphical representation of questionnaire data.

Table 2. Path analysis results for regression weights.

Regression Weights (Group Number 1—Default Model)							
			Estimate	***S.E.***	***C.R.***	***P***	***Label***
PrefertoAlt	<---	Count	-.046	.010	-4.481	***	
PrefertoAlt	<---	Mean_Duration	.620	.377	1.643	.100	
PrefertoAlt	<---	UserFriendly	-.446	.104	-4.278	***	
PrefertoAlt	<---	TrackProgress	.151	.146	1.033	.301	
PrefertoAlt	<---	EaseOfUse	.670	.094	7.149	***	
IntroduceFriends	<---	PreferToAlt	.454	.064	7.038	***	
TellOthers	<---	PreferToAlt	.567	.050	11.265	***	

Table 3. Path analysis results for variances.

Variances (Group Number 1—Default Model)					
	Estimate	***S.E.***	***C.R.***	***P***	***Label***
e5	2.781	.304	9.138	***	
e4	1.143	.125	9.138	***	
e3	2.245	.246	9.138	***	
e2	.172	.019	9.138	***	
e1	234.413	25.653	9.138	***	
e6	4.082	.447	9.138	***	
e7	4.413	.483	9.138	***	
e8	2.687	.294	9.138	***	

are three variables that significantly affect users' preference for this product over alternatives. Moreover, the preference for this product increases the likelihood of users introducing this product to their friends.

In the factor analysis, two out of three subjective exogenous variables (i.e., User-Friendly, Track Progress, Ease of Use) are significantly related to the same factor; Track Progress is not, so the variable is removed from the analysis. Both of the objective exogenous variables (i.e., Count, Mean Duration) are significant, so they can be used as independent variables. For subjective endogenous variables, the variable Tell Others is not significantly related to the same factor as Introduce Friends. The effect size of Tell Others is large, so we consider it a dependent variable. The regression weights, covariance, and variances are shown in Tables 2 and 3, followed by the results of the reliability analysis in Table 4.

COMMUNITY IMPACT

Community impact was considered from the conception of the idea, both globally and locally. The testing showed a high approval from clients at 64%. Even though this application won't have immediate results, the long-term prevention is worth the effort on the prospective service recipient or client's behalf. The app prototype also provided a quiz users could take to see if they had the disease symptoms. If the user had the symptoms of the disease, the location of their nearest health care provider was given. Another feature of the application, which is in beta testing, was predicting

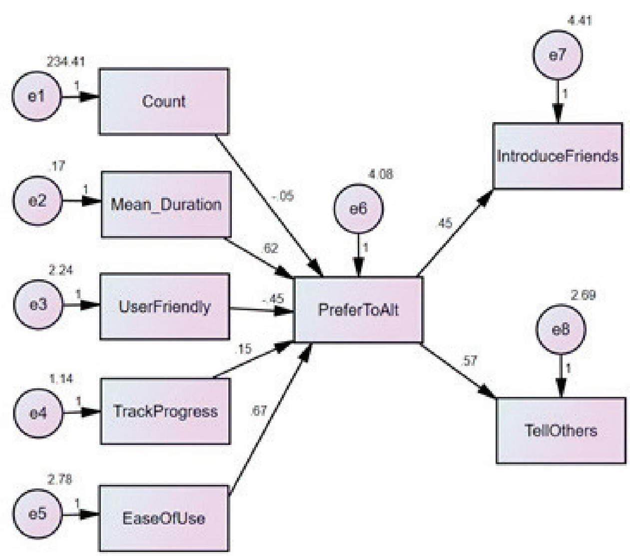

Figure 5. Path analysis of observed variables into dependent variable.

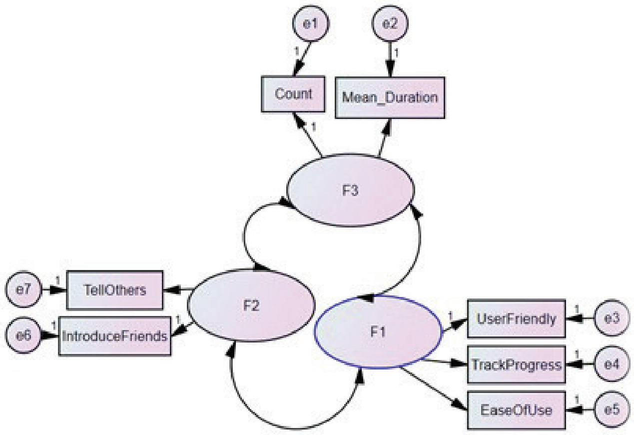

Figure 6. Factor analysis.

disease outbreaks based on statistics. Since the application informed users about diseases, it was considered a success. This publication can provide inspiration for others to follow up in future work.

STUDENT IMPACT

The experience of creating a smart application provided insights on smart service-learning systems. Having a design project where the end goal is to create a product the client would approve of supports professional development and prepares us for the industry. The design-focused thought process we have used for many years as industrial engineering students, as well as the new skills we have acquired in IE486, were employed. Many human factor concepts and design analysis techniques were used to create this application. Our experiences and classes prepared us for this type of smart design challenge and put our skills to the test in a real-life setting. Throughout the design process of our smart disease prevention application, we became familiar with task analysis, AHP analysis, heuristic analysis, and other methods of analysis. This project was unique, and it pushed the team to think in new and innovative ways that will be essential as we move into the business industry or higher education. We would have preferred more time to take the project farther into a programmed beta-testing phase to better predict the impact of this application. It would also have been an asset for students to check updates regularly when traveling.

Table 4. Reliability analysis.

Reliability Statistics	
Cronbach's Alpha	***N of Items***
.780	6

CONCLUSION

Due to a lack of communication and prior experience, some results may not be generalizable beyond the results of the student users tested in the lab. The subjects didn't know they had to fill out the questionnaire while taking the eye-tracking test, and many of the appointments were delayed because studies took longer than expected. Going forward, when presenting this application to health care providers, clear instructions are needed for how the application should be used both on the service recipient's end and for those who will provide data about local illness statistics included in the app. This is a crucial step in the implementation of the application to expedite its success. We gained an appreciation for volunteers who participate in research studies. The data collection portion of this project gave our group an understanding of how difficult it can be for a researcher to get his or her data to improve and refine a design. It's hard to find willing volunteers who will contribute to an accurate study. In today's society, this is a perfect way to reach out to people in the community and inform them about disease outbreaks and, over time, predict outbreaks.

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